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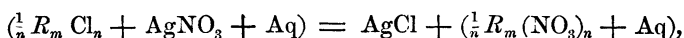
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		°		
1	Sodic Chloride NaCl	.760	} 16,220	+65
2	" " "	.750		
3	Potassic Chloride KCl	.750	} 16,110	-55
4	" " "	.750		
5	Ammonic Chloride NH ₄ Cl	.755	} 16,170	+5
6	" " "	.750		
7	Barium Chloride BaCl ₂	.750	16,110	-55
8	Cupric Chloride CuCl ₂	.757	16,270	+115
9	Zinc Chloride ZnCl ₂	.760	16,320	+165
10	Manganese Chloride MnCl ₂	.745	16,010	-155
11	Nickel Chloride NiCl ₂	.755	} 16,110	-55
12	" " "	.745		
13	Ferrous Chloride FeCl ₂	.745	16,010	-155
14	Aluminic Chloride Al ₂ Cl ₃	.745	16,010	-155
15	Ferric Chloride Fe ₂ Cl ₃	1.520*	} 16,320	+165
16	" " "	.760		
17	Chromic Chloride Cr ₂ Cl ₃	.760	16,320	+155
18	Hydrochloric Acid HCl	.760	} 16,170	+5
19	" " "	.740		
20	" " "	.755		
	Average	.7526	16,165	

It will be seen that all of these results are identical within the limit of error of the process. We may, therefore, draw the conclusion, that the amount of heat evolved by the reaction thus represented,



is constant, no matter what R , m , or n may be.

Hence, also, *the difference between the heats of formation of equivalent amounts of nitrate and chlorides in aqueous solution is the same for any metal or basic radical.*

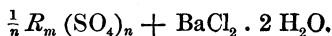
IV.—IS THERE A CONSTANT RELATION BETWEEN THE HEATS OF FORMATION OF CHLORIDES AND SULPHATES IN AQUEOUS SOLUTION?

By IRVING W. FAY, A. B. 1886.

THE series of results obtained by Mr. Richards, as above described, suggested the inquiry whether a like constant relation might not be found between the heats of formation of the *chlorides* and *sulphates* in

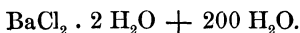
* In this experiment 8 grms. of AgNO₃ were used.

aqueous solution. Accordingly, a series of experiments was made involving this general reaction,



All work was done in a constant-temperature room. The calorimeter was the one used by Mr. Richards, and the accessories were in every respect the same as those described by him.

The materials required were a standard solution of barium chloride, and a solution of each of the sulphates to be acted upon containing a sufficient excess to insure complete precipitation of the barium. Accordingly, a standard solution of barium chloride was made of the strength represented by the expression,



From this standard value the required amount of each sulphate was easily calculated.

For every experiment, 250 cc. of the baric chloride and 250 cc. of the sulphate solution were used. Hence this amount of water, increased by the water equivalent of the calorimeter, stirrer, and thermometer, gave the total water equivalent, which was exactly the same for each experiment.

The mode of experimenting was precisely like that in the preceding paper, and the maximum rise of temperature took place in less than fifteen seconds, which rendered unnecessary any correction for cooling. The limit of error did not exceed $0^\circ.02 \text{ C.}$, and if any accidental cause of uncertainty arose, a second experiment was made for confirmation.

The following example is taken at random from the note-book:—

Temperature of BaCl_2 sol. in calorimeter . . .	16°.94
“ “ Na_2SO_4 sol. in beaker . . .	16°.78
Mean	16°.86
Final observed temperature	17°.50
Rise of temperature	0°.64

The last column of the following table shows the amount of heat produced by the reaction of one molecule (244 grams) of baric chloride upon one molecule of sulphuric acid in combination with a base, both being in aqueous solution. The next column to the left gives the observed rise of temperature; and, since the amount of baric

chloride used was the same in every case, the values in either column may be directly compared with each other.

		o	c.
1.	BaCl ₂ and Na ₂ SO ₄	.64	5171
2.	" " Na ₂ SO ₄	.63	5089
3.	" " K ₂ SO ₄	.68	5594
4.	" " (NH ₄) ₂ SO ₄	.70	5556
5.	" " MgSO ₄	.70	5556
6.	" " ZnSO ₄	.70	5556
7.	" " CdSO ₄	.715	5776
8.	" " CuSO ₄	.685	5534
9.	" " NiSO ₄	.71	5736
10.	" " CoSO ₄	.71	5736
11.	" " FeSO ₄	.72	5817
12.	" " $\frac{1}{3}$ Al ₂ (SO ₄) ₃	.805	6504
13.	" " $\frac{1}{3}$ Al ₂ (SO ₄) ₃	.805	6504
14.	" " $\frac{1}{3}$ Fe ₂ (SO ₄) ₃	.85	6864
15.	" " $\frac{1}{3}$ Fe ₂ (SO ₄) ₃	.85	6864
16.	" " $\frac{1}{4}$ K ₂ Al ₂ (SO ₄) ₄	.83	6704
17.	" " $\frac{1}{4}$ K ₂ Al ₂ (SO ₄) ₄	.81	6544
18.	" " $\frac{1}{4}$ K ₂ Cr ₂ (SO ₄) ₄	.80	6464
19.	" " $\frac{1}{4}$ K ₂ Cr ₂ (SO ₄) ₄	.79	6184
20.	" " $\frac{1}{4}$ (NH ₄) ₂ Fe ₂ (SO ₄) ₄	1.02	8240
21.	" " $\frac{1}{4}$ (NH ₄) ₂ Fe ₂ (SO ₄) ₄	1.03	8320
22.	" " H ₂ SO ₄	1.225	9904

The first noticeable fact observed in the above table is, that the difference between the heats of formation of chloride and *sulphate* is *not* the same for all metals, as it was found to be in the case of the chlorides and *nitrates*. It will be noticed, however, that with sulphates of allied bases the agreement is as close as before, but the sesquioxide salts give a larger amount of heat than the protoxide, and the double salts a still larger quantity, and sulphuric acid much the largest of all. It is a singular fact, that in the case of common alum the heat evolved is greater than it is with either of its constituent salts.